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(71) Applicants (*for all designated States except US*):
TEMPLE UNIVERSITY - OF THE COMMON-WEALTH SYSTEM OF HIGHER EDUCATION [US/US]; Broad Street and Montgomery Avenue, Philadelphia, PA 19122 (US). **THE BOARD OF REGENTS OF THE UNIVERSITY OF OKLAHOMA** [US/US]; 600 Parrington Oval, Norman, OK 73019 (US). **PHILADELPHIA UNIVERSITY** [US/US]; School House Lane and Henry Avenue, Philadelphia, PA 19144 (US).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **KHOURY, Naji, N.** [LB/US]; 1011 Federal Street, Philadelphia, PA 19147 (US). **KHOURY, Charbel, Najib** [LB/US]; 1220 E. Brooks Street, Norman, OK 73071 (US). **ABOUSLEIMAN, Younane, Nassib** [US/US]; 2817 Castlewood Drive, Norman, OK (US). **ROSTAMI, Hossein** [US/US]; 6 Gunning Lane, Gladwyne, PA 19035 (US). **YADA,**

Damodar [IN/US]; 1229 Chestnut Street, Apt. #1308, Philadelphia, PA 19107 (US).

(74) Agents: **MONACO, Daniel, A.** et al.; Drinker Biddle & Reath LLP, One Logan Square, Ste. 2000, Philadelphia, PA 19103-6996 (US).

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(54) Title: PLASTIC-BASED CEMENTITIOUS MATERIALS

(57) Abstract: A plastic-based cementitious material is prepared by heating a mixture comprising plastic, sand and SiO_x nanoparticles. The material is resistant to corrosive environments and is useful as a construction material.



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PLASTIC-BASED CEMENTITIOUS MATERIALS

Cross-Reference to Related Application

[0001] The benefit of the filing date of U.S. Provisional Patent Application No. 61/441,449, filed February 10, 2011, is hereby claimed. The entire disclosure of the aforesaid application is incorporated herein by reference.

Field of Invention

[0002] The invention relates to a novel plastic-based cementitious material that is resistant to acidic environments and undergoes little alteration in volume or mass when exposed to a corrosive environment. The material may find use in the preparation of pipes and other construction structures that have to withstand corrosive conditions for extended periods of time.

Background of Invention

[0003] "Cement" is the general term used to describe a binder, i.e., a substance that sets and hardens independently and can bind other materials together. The cement used in construction may be hydraulic or non-hydraulic. A hydraulic cement (such as Portland cement) hardens because of hydration chemical reactions that occur independently of the mixture's water content; it can harden even under water or when constantly exposed to wet weather. A non-hydraulic cement (such as lime and gypsum plaster) must be kept dry in order to retain its strength.

[0004] The most important use of cement is the production of concrete. Concrete is a composite construction material that is composed of cement (commonly Portland cement) and other cementitious materials, such as fly ash and slag cement, aggregate (which comprises gravels or crushed rocks, such as limestone or granite), water and chemical admixtures. Concrete should not be confused with cement because cement refers only to the anhydrous powder substance (ground clinker) used to bind the aggregate materials of concrete. Upon the addition of water and/or additives, the cement mixture is referred to as concrete, especially if aggregates have been added.

[0005] Concrete solidifies and hardens after mixing with water, eventually creating a robust stone-like material. Concrete is used to make pavements, pipes, architectural structures, foundations, roads, bridges, overpasses, parking structures,

brick, block walls, and footings for gates, fences and poles. Concrete is the most used man-made material in the world. According to the U.S. Geographic Service, about 7.5 cubic kilometers of concrete are made each year — more than one cubic meter for every person on Earth.

[0006] Concrete can be damaged by many processes, such as the expansion of corrosion products of the steel reinforcement bars, freezing of trapped water, fire or radiant heat, aggregate expansion, sea water effects, bacterial corrosion, leaching, erosion by fast-flowing water, physical damage, and chemical damage (from carbonation, chlorides, sulfates and distillate water). The adverse effect of sulfuric acid on Portland cement concrete sewer pipes is a well known phenomenon (Guadalupe *et al.*, *Cement and Concrete Research* 40(2):293-301 (2010); Davies *et al.*, *Urban Water*, 3(1-2)73-89 (2001)). Sulfuric acid attacks the calcium hydroxide and calcium silicate hydrate present in concrete, forming calcium sulfate, which then reacts with calcium aluminate hydrate to form ettringite (Skalny *et al.*, (2003) “Sulfate Attack on Concrete”, Taylor and Francis e-library; Neville, A. M., *Properties of Concrete*. John Wiley & Sons, Inc., New York, NY, USA (1996). These reactions result in volume expansion of the concrete material, thus leading to their deterioration. Such problems are often observed in concrete pipes, which are commonly exposed to acidic solutions for extended periods of time. There is thus a need for developing novel materials that have improved chemical stability over concrete and can be used to replace concrete as a building material.

[0007] Recently, due to the high increase of plastic waste in the world, there has been an increased interest in using recycled materials in civil engineering construction. Such utilization is advantageous from both environmental and economic standpoints. A report by MSW (Municipal Solid Waste) indicated that 246 million tons of waste were generated in the USA in 2005, of which 11.8% consists of plastic waste. Table 1 itemizes the total yearly amounts of plastic waste. Only 6% of the plastics were recovered, while the remainder was discarded in landfills. Increasing the percentage of recycling would have an obviously positive impact on the environment.

Table 1. Total Plastics in Municipal Solid Waste (in thousands of tons).

Product name	Generation	Recovery	Discards
PET	2,860	540 (~19%)	2,320
HDPE	5,890	420 (~ 7%)	5,370
PVC	1,640	--- (0%)	1,640
LDPE/LLDPE	6,450	190 (~ 3%)	6,260
PP	4,000	10 (0.25%)	3,990
PS	2,590	--- (0%)	2,590
Other resins	5,480	390 (~7%)	5,090
Total Plastics in MSW	28,910	1,650 (5.7%)	27,260

[0008] Polyethylene terephthalate (PET) is one of the most common consumer plastics used, and is widely employed as a raw material in products such as soft-drink bottles and food containers. PET bottles have in fact taken the place of glass bottles as the preferred storage vessel of beverages due to their light weight and easiness of handling. In 2007, the world's annual consumption of PET bottles was approximately 10 million tons, and that number tends to grow about up to 15% every year. Unfortunately, the level of recycling of bottles is still very low: approximately 3.6 billion pounds of PET bottles are not recycled per year.

[0009] The exponential growth in plastic waste from packaging incited a search for alternative uses for the plastic waste (Marzouk et al., 2007, Waste Management 27:310-18). The sorted post-consumer PET waste may be crushed and shredded into small fragments or flakes, which may be used as additives to concrete, along with the traditional cementitious binders. Recycled PET has been used to generate plastic-containing concrete composites (Siddique et al., 2008, Waste Management 28:1835-52), but the material is highly sensitive to temperature changes (Sam & Tam, 2002, "Polymer concrete based on recycled polyethylene terephthalate (PET)", NOCMAT/3. In: Vietnam International Conference on Non-Conventional Material and Technologies, pp. 226-28; Rebeiz, 1996, Constr. & Build. Mat. 10:215-20). In fact, plastic shrinkage cracking is a primary cause of reduced performance in PET-containing cement composites (Ochi et al., 2007, Cement & Concrete Comp. 29:448-55; Silva et al., 2005, Cement & Concrete Comp. 35:1741-46; Frigione, 2010, Waste

Management 30:1101-06; Bentur & Mindess, 1990, "Fibre Reinforced Cementitious Composites", Elsevier Applied Science, London, pp. 1-11; Won & Park, 1999, Journal KSCE 15(5):783-90). In these plastic composites, where the plastic is used along with the standard ingredients of cement, the poor mechanical bond of the plastic materials with the cement-based composite causes structural failures (Sehaj et al., 2004, Cement & Concrete Res. 34(10):1919-25; Li et al., 1994, "Interface strengthening mechanisms in polymeric fiber reinforced cementitious composites." In: Proceeding of International Symposium of Brittle Matrix Composites, Warsaw, September 13-15, IKE and Woodhead Publish, Warsaw, pp. 7-16; Mobasher and Li, 1996, Adv. Cement Based Materials 4(3-4):93-105; Shannag et al., 1997, Cement & Concrete Res. 27(6):925-36; Akcaözoğlu et al., 2010, Waste Management 30(2):285-90). As a consequence, PET-containing cement composites have not risen to the level of quality and reliability that would allow them to be commercially used in large scale as construction materials.

[0010] There is thus a great need to identify a novel material that may replace concrete in applications where the construction material is subjected to corrosive environments. In one aspect, such novel material would comprise waste plastic as a cheap and readily available component, without sacrificing structural integrity or chemical resistance. This would allow waste plastics to find new and economical uses, avoiding their accumulation in the environment. The present invention addresses this need.

Summary of Invention

[0011] As described herein, the inventors have surprisingly discovered a novel plastic-based cementitious material. The material of the invention may be used under corrosive conditions and has superior resistance properties as compared to conventional cements.

[0012] The plastic-based cementitious material is prepared by a method comprising the steps of providing a mixture comprising a first amount of a plastic, a second amount of sand, and a third amount of SiO_x nanoparticles; homogenizing the mixture; and heating the mixture to a given temperature for a given amount of time, thereby affording the plastic-based cementitious material.

[0013] In some embodiments, the mixture is essentially free of cementitious binders. In some embodiments, the mixture consists essentially of plastic, sand and SiO_x nanoparticles. In other embodiments, the mixture consists of plastic, sand and SiO_x nanoparticles.

[0014] In some embodiments, the plastic-based cementitious material is essentially free of cementitious binders.

[0015] In one embodiment, the ratio of the plastic amount to the sand amount ranges from about 10 : 1 to about 1 : 10, by weight. In another embodiment, the ratio of the plastic amount to the sand amount ranges from about 3 : 1 to about 1 : 3, by weight. In yet another embodiment, the ratio of the plastic amount to the sand amount is about 1 : 1. In yet another embodiment, the amount of the SiO_x nanoparticle ranges from about 0.1% to about 10% of the plastic amount, by weight. In yet another embodiment, the amount of the SiO_x nanoparticle ranges from about 1% to about 5% of the plastic amount, by weight.

[0016] In one embodiment, the plastic comprises a material selected from the group consisting of PET, HDPE, PVC, LDPE, LLDPE, PP and PS. In another embodiment, the plastic comprises PET. In yet another embodiment, the sand comprises ASTM C-33 sand. In yet another embodiment, the SiO_x nanoparticles have an average particle size ranging from about 1 nm to about 500 nm. In yet another embodiment, the SiO_x nanoparticles have an average particle size ranging from about 5 nm to about 250 nm. In yet another embodiment, the SiO_x nanoparticles have an average particle size ranging from about 5 nm to about 100 nm. In yet another embodiment, the SiO_x nanoparticles have an average particle size of about 15 nm. In yet another embodiment, 'x' ranges from about 1 to about 2. In yet another embodiment, 'x' ranges from about 1.2 to about 1.8. In yet another embodiment, 'x' ranges from about 1.2 to about 1.6. In yet another embodiment, the given temperature is equal or higher than about the melting temperature of the plastic. In yet another embodiment, the plastic comprises PET and the given temperature is about 265 °C.

[0017] A method of preparing a plastic-based cementitious material is provided. In a preferred embodiment, the method comprises the steps of providing a mixture of a first amount of a plastic, a second amount of sand, and a third amount of SiO_x nanoparticles; homogenizing the mixture; and heating the mixture to a given

temperature for a given amount of time, thereby affording the plastic-based cementitious material. In some embodiments, the mixture is essentially free of cementitious binders. In some embodiments, the mixture consists essentially of plastic, sand and SiO_x nanoparticles. In other embodiments, the mixture consists of plastic, sand and SiO_x nanoparticles.

[0018] In one embodiment of the method, the ratio of the plastic amount to the sand amount ranges from about 10 : 1 to about 1 : 10, by weight. In another embodiment, the ratio of the plastic amount to the sand amount ranges from about 3 : 1 to about 1 : 3, by weight. In yet another embodiment, the ratio of the plastic amount to the sand amount is about 1 : 1, by weight. In yet another embodiment, the amount of the SiO_x nanoparticles ranges from about 0.1% to about 10% of the plastic amount, by weight. In yet another embodiment, the amount of SiO_x nanoparticles ranges from about 1% to about 5% of the plastic amount, by weight.

[0019] In one embodiment, the plastic comprises a material selected from the group consisting of PET, HDPE, PVC, LDPE, LLDPE, PP and PS. In another embodiment, the plastic comprises PET. In yet another embodiment, the sand comprises ASTM C-33 sand. In yet another embodiment, the SiO_x nanoparticles have an average particle size ranging from about 1 nm to about 500 nm. In yet another embodiment, the SiO_x nanoparticles have an average particle size ranging from about 5 nm to about 250 nm. In yet another embodiment, the SiO_x nanoparticles have an average particle size ranging from about 5 nm to about 100 nm. In yet another embodiment, the SiO_x nanoparticles have an average particle size of about 15 nm. In yet another embodiment, 'x' ranges from about 1 to about 2. In yet another embodiment, 'x' ranges from about 1.2 to about 1.8. In yet another embodiment, 'x' ranges from about 1.2 to about 1.6. In yet another embodiment, the given temperature is equal or higher than about the melting temperature of the plastic. In yet another embodiment, the plastic comprises PET and the given temperature is about 265 °C.

[0020] As envisioned in the present invention with respect to the disclosed compositions of matter and methods, in one aspect the embodiments of the invention comprise the components and/or steps disclosed therein. In another aspect, the embodiments of the invention consist essentially of the components and/or steps

disclosed therein. In yet another aspect, the embodiments of the invention consist of the components and/or steps disclosed therein.

Description of Figures

[0021] Figure 1 illustrates a micrograph of SiO_x nanoparticles used in Example 1.

[0022] Figure 2 is a graph illustrating the dependency of unconfined compressive strength (UCS) of the plastic-based cementitious material of the invention on the amount of SiO_x nanoparticles used to prepare the material.

[0023] Figure 3 is a series of photographs depicting plastic-based cementitious specimens immersed in a 4 M sulfuric acid solution.

[0024] Figure 4 is a graph illustrating the weight change of plastic-based cementitious material specimens of the invention ("PBC"), Sauereisen 265, and other admixture-modified concrete specimens when exposed to sulfuric acid.

Definitions

[0025] The definitions used in this application are for illustrative purposes and do not limit the scope used in the practice of the invention.

[0026] Unless defined otherwise, all technical and scientific terms used herein generally have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Generally, the nomenclature used herein and the laboratory procedures in chemistry, analytical chemistry, lipid chemistry, geochemistry and mineralogy are those well known and commonly employed in the art.

[0027] The articles "a" and "an" are used herein to refer to one or to more than one (i.e. to at least one) of the grammatical object of the article. By way of example, "an element" means one element or more than one element.

[0028] The term "about" will be understood by persons of ordinary skill in the art and will vary to some extent on the context in which it is used.

[0029] As used herein, the term "cementitious binder" refers to any material that is incorporated into cement for the purpose of binding particles together as a coherent mass and is not silica or sand. Non-limiting examples of cementitious binders are cement, fly ash, slag cement, limestone, granite, iron oxide, alumina, calcium carbonate, and gypsum.

[0030] As used herein, a first material is “essentially free” of a second material if the first material contains less than 5% by weight of the second material, preferably less than 4% by weight of the second material, more preferably less than 3% by weight of the second material, even more preferably less than 2% by weight of the second material, even more preferably less than 1% by weight of the second material, and even more preferably less than 0.5% in weight of the second material.

[0031] As used herein regarding SiO_x , ‘x’ refers to the ratio of oxygen to silicon in that material.

Detailed Description of Invention

[0032] The present invention is based on the unexpected discovery of a novel plastic-based cementitious material. The material is prepared from a mixture of a plastic, sand and silica (SiO_x) nanoparticles. According to the invention, the mixture is homogenized and heated to a temperature that is equal to or higher than about the melting temperature of the plastic, and the plastic-based cementitious material is thereby formed. The material of the invention is unexpectedly resistant to corrosive environments, such as corrosive fluids, and may be used to create structures, such as pipes, sewer pipes, foundations and retaining walls, which are often exposed to corrosive environments.

[0033] The plastic-based cementitious material may be prepared from a mixture consisting essentially of a plastic, sand and silica (SiO_x) nanoparticles. A plastic that melts at a temperature lower than its decomposition temperature is useful within the compositions and methods of the invention. In order to facilitate the use of the polymer within the compositions and methods of the invention, the polymer may be shredded to pieces or grounded to flakes. Non-limiting examples of plastics contemplated within the compositions and methods of the invention are polyethylene terephthalate (PET), high-density polyethylene (HDPE), PVC (polyvinyl chloride), low-density polyethylene (LDPE), liner low-density polyethylene (LLDPE), PP (polypropylene) and PS (polystyrene). PET is a preferred plastic within the compositions and methods of the invention. The molecular formula for the PET monomer is $\text{C}_{10}\text{H}_8\text{O}_4$. The melting point of PET is approximately 265 °C and its glass temperature is approximately 80 °C.

[0034] The sand useful within the compositions and methods of the invention should be essentially free of organic and inorganic contaminants, especially cementitious binders. The diameter of sand grains may range from 62.5 μm (1/16 mm) to 2 mm, including the following size subcategories: very fine sand (1/16 mm – 1/8 mm diameter), fine sand (1/8 mm – 1/4 mm diameter), medium sand (1/4 mm – 1/2 mm diameter), coarse sand (1/2 mm – 1 mm diameter), and very coarse sand (1 mm – 2 mm diameter).

[0035] The SiO_x nanoparticles useful within the compositions and methods of the invention may be obtained from commercial sources or prepared according to methods known to those skilled in the art. SiO_x nanoparticles are silicon oxide particles with average diameters below 1 μm . Due to the large surface area of the material, the atomic ratio of silicon to oxygen for the SiO_x nanoparticles is not 2:1 as in SiO_2 . In one embodiment, the 'x' value in the SiO_x nanoparticles ranges from about 1.0 to about 2.0. In another embodiment, the 'x' value ranges from about 1.2 to about 1.8. In another embodiment, the 'x' value ranges from about 1.2 to about 1.6. Preferentially, the SiO_x nanoparticles useful within the compositions and methods of the invention range in diameter from about 1 nm to about 500 nm, or any interval thereinbetween.

[0036] The plastic-based cementitious material of the invention may be prepared from a plastic, silica and SiO_x nanoparticles. In a preferred embodiment, the mixture is essentially free of cementitious fillers. The mixture is stirred and homogenized using equipment known to those in the art, such as mixers and tumblers. As the composition is homogenized, it is heated to a temperature that is equal to or higher than about the melting point of the plastic. In one preferred embodiment, the mixture is heated to about the melting temperature of the plastic. Upon melting of the plastic, a composition comprising the molten plastic-based cementitious material is formed. Without wishing to be bound by any theory, upon heating of the mixture, bonds are believed to be formed between the plastic and the SiO_x nanoparticles, resulting in a plastic-based cementitious material that is unexpectedly resistance to chemical corrosion.

[0037] As envisioned by the present invention, the molten plastic-based cementitious material may be molded into any shape required for its use and then allowed to solidify into that shape. Alternatively, the plastic-based cementitious

material may be cooled and solidified into blocks. These blocks may be divided in smaller blocks and used as necessary. The plastic-based cementitious materials can also be used as grouting and coating material for the rehabilitation of existing sewer pipes and other structures.

[0038] Although the invention has been described in its preferred form with a certain degree of particularity, obviously many changes and variations are possible therein and will be apparent to those skilled in the art after reading the foregoing description. For example, the materials of the present invention may also be useful as construction material to build swimming pools or other structures that hold liquids. It is therefore to be understood that the present invention may be presented otherwise than as specifically described herein without departing from the spirit and scope thereof.

[0039] The invention should not be construed to be limited solely to the compositions and methods described herein, but should be construed to include other compositions and methods as well. One of skill in the art will know that other compositions and methods are available to perform the procedures described herein.

Examples

[0040] The invention is described hereafter with reference to the following examples. The examples are provided for the purpose of illustration only and the invention should in no way be construed as being limited to these examples, but rather should be construed to encompass any and all variations that become evident as a result of the teaching provided herein.

Materials

[0041] PET flakes, produced from recycled plastic bottles, were supplied by Greenpoint Industries, Inc. (Rancho Dominguez, CA).

[0042] The gradation of the sand used in this study is shown in Table 2:

Table 2.

Grain Size (cm)	% Passing
9.5	100.0
4.75	100.0
2.36	100.0
1.18	99.5
0.6	90.8
0.3	33.5
0.15	2.87

[0043] SiO_x (silicon oxide) nanoparticles were supplied by Nanostructured & Amorphous Materials, Inc. (Houston, TX), and their properties are summarized in Table 3. An illustrative micrograph of SiO_x particles is reproduced in Figure 1.

Table 3.

Purity	99.5 %
APS	15 nm
SSA	~640 m ² /g
Color	white
Morphology	spherical, porous
bulk density	0.10 g/cm ³
trur density	2.2 – 2.6 g/cm ³
Al, Ca	< 0.002 %
Fe, Mg, Cl	< 0.001 %

Example 1: Preparation of Plastic-Based Cementitious Material (PBCM)

[0044] PET flakes, sand and SiO_x (silicon oxide) were dried in an oven for 24 hours at 110 °C, prior to melt processing. The plastic-based cementitious material was produced by simultaneously heating and mixing PET flakes, sand and SiO_x so that a uniform mixture was attained. The plastic-to-sand (P/S) weight ratio used in this experiment was 1:1. SiO_x was added at concentrations of 1%, 1.5% and 2.5% per weight based on the dry weight of the PET. The temperature was kept at 265 °C during the mixing process.

Example 2: Measurement of Unconfined Compressive Strength

[0045] Limited UCS (unconfined compressive strength) tests were performed on the PBCM specimens prepared in Example 1, under standard conditions (in the absence of sulfuric acid treatment), as summarized in Figure 2 and Table 4. The results suggest that the average compressive strength of the PBCM specimens increased with the amount of SiO_x used in the preparation of the PBCM specimens.

Table 4. Summary of UCS of various PBCM mixes.

Mix Design No.	P/S	% of SiO_x *	Average (UCS) (psi)
1	1	0	5,310
2	1	1	5,517
3	1	1.5	5,782
4	1	2.5	6,904

* SiO_x is added based on the dry weight of PET

Example 3: Behavior of Plastic-Based Cementitious Material (PBCM) under Sulfuric Acid Exposure

[0046] Cylindrical and cubical specimens of PBCM were prepared according to Example 1 and cured for 1 day. The PBCM cubes and cylinders ((prepared with 1% SiO_x) were then immersed into a 4 M sulfuric acid solution (Figure 3). After specific time periods of exposure, the specimens were removed from the acidic solution, dried and measured for changes in weight and dimensions. Figure 4 illustrates variations in weight as a function of exposure time of the PBCM. Sauereisen Epoxy Novolak Polymer Concrete No. 265 (Pittsburgh, PA) ("Sauereisen 265"), Geopolymer and other admixture-modified concrete cements were used to assess the performance of the PBCM specimens. "Geopolymer" is a geopolymer mortar specimen prepared according to Thokchom *et al.*, *ARPN Journal of Engineering and Applied Sciences*, 4(1):65-70- (2009). "Goyal *et al.* 2009" is a concrete specimen prepared with mineral admixtures according to Goyal *et al.*, *J. Advanced Concrete Technology* 7(2):273-283 (2009). "Bassuoni and Nehdi, 2007" represents a self-consolidating concrete prepared according to Bassuoni and Nehdi, *Cement and Concrete Research* 37(7):1070-1084 (2007); "Hewayde *et al.* 2007" represents a concrete specimen prepared with admixtures according to Hewayde *et al.*, *J. Mat. in Civ. Engrg.* 19(2): 155-163 (2007).

Sauereisen 265 is a standard cement is specifically formulated for foundation construction. It is resistant to a wide range of solvents, oils, acids and acid salts (except hydrofluoric) over a pH range of 0.0 to 14.0. The result suggests that the specimens of PBCM underwent minimal changes in weight upon exposure to sulfuric acid.

[0047] Visual inspection of the specimens did not indicate any perceptible degradation of the PBCM. Taken together, the experiments reported herein suggest that the PBCM showed good resistance to sulfuric acid.

[0048] The disclosures of each and every patent, patent application, and publication cited herein are hereby incorporated herein by reference in their entirety. One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. While the invention has been disclosed with reference to specific embodiments, it is apparent that other embodiments and variations of this invention may be devised by others skilled in the art without departing from the true spirit and scope used in the practice of the invention. The appended claims are intended to be construed to include all such embodiments and equivalent variations.

CLAIMS

What is claimed:

1. A composition comprising a plastic-based cementitious material essentially free of cementitious binders wherein the composition is prepared by a method comprising the steps of:

- (a) providing a mixture comprising an amount of a plastic, an amount of sand, and an amount of SiO_x nanoparticles;
- (b) homogenizing the mixture; and,
- (c) heating the mixture to a given temperature for a given amount of time, thereby providing the plastic-based cementitious material.

2. The composition of claim 1, wherein the ratio of the plastic amount to the sand amount ranges from about 10 : 1 to about 1 : 10, by weight.

3. The composition of claim 2, wherein the ratio of the plastic amount to the sand amount ranges from about 3 : 1 to about 1 : 3, by weight.

4. The composition of claim 3, wherein the ratio of the plastic amount to the sand amount is about 1 : 1, by weight.

5. The composition of claim 1, wherein the SiO_x nanoparticles amount ranges from about 0.1% to about 10% of the plastic amount, by weight.

6. The composition of claim 5, wherein the SiO_x nanoparticles amount ranges from about 1% to about 5% of the plastic amount, by weight.

7. The composition of claim 1, wherein the plastic comprises a material selected from the group consisting of PET, HDPE, PVC, LDPE, LLDPE, PP and PS.

8. The composition of claim 7, wherein the plastic comprises PET.
9. The composition of claim 1, wherein the sand comprises ASTM C-33 sand.
10. The composition of claim 1, wherein the SiO_x nanoparticles have an average particle size ranging from about 500 nm to about 1 nm.
11. The composition of claim 10, wherein the SiO_x nanoparticles have an average particle size ranging from about 250 nm to about 5 nm.
12. The composition of claim 11, wherein the SiO_x nanoparticles have an average particle size ranging from about 100 nm to about 5 nm.
13. The composition of claim 12, wherein the SiO_x nanoparticles have an average particle size of about 15 nm.
14. The composition of claim 1, wherein the given temperature is equal or higher than about the melting temperature of the polymer.
15. The composition of claim 14, wherein the plastic comprises PET and the given temperature is about 265 °C.
16. The composition according to claim 1, wherein the mixture provided in step (a) consists essentially of plastic, sand and SiO_x nanoparticles.
17. The composition according to claim 1 comprising a plastic-based cementitious material essentially free of cementitious binders.
18. A method of preparing a composition comprising a plastic-based cementitious material, wherein the method comprises the steps of:

- (a) providing a mixture comprising an amount of a plastic, an amount of sand, and an amount of SiO_x nanoparticles;
- (b) homogenizing the mixture; and,
- (c) heating the mixture to a given temperature for a given amount of time, thereby providing the plastic-based cementitious material.

19. The method of claim 18, wherein the ratio of the plastic amount to the sand amount ranges from about 10 : 1 to about 1 : 10, by weight.

20. The method of claim 19, wherein the ratio of the plastic amount to the sand amount ranges from about 3 : 1 to about 1 : 3, by weight.

21. The method of claim 20, wherein the ratio of the plastic amount to the sand amount is about 1 : 1, by weight.

22. The method of claim 18, wherein the SiO_x nanoparticles amount ranges from about 0.1% to about 10% of the plastic amount, by weight.

23. The method of claim 22, wherein the SiO_x amount ranges from about 1% to about 5% of the plastic amount, by weight.

24. The method of claim 18, wherein the plastic comprises a material selected from the group consisting of PET, HDPE, PVC, LDPE, LLDPE, PP and PS.

25. The method of claim 24, wherein the plastic comprises PET.

26. The method of claim 18, wherein the sand comprises ASTM C-33 sand.

27. The method of claim 18, wherein the SiO_x nanoparticles have an average particle size ranging from about 1 nm to about 500 nm.

28. The method of claim 27, wherein the SiO_x nanoparticles have an average particle size ranging from about 5 nm to about 250 nm.

29. The method of claim 28, wherein the SiO_x nanoparticles have an average particle size ranging from about 5 nm to about 100 nm.

30. The method of claim 29, wherein the SiO_x nanoparticles have an average particle size of about 15 nm.

31. The method of claim 18, wherein the given temperature is equal or higher than about the melting temperature of the plastic.

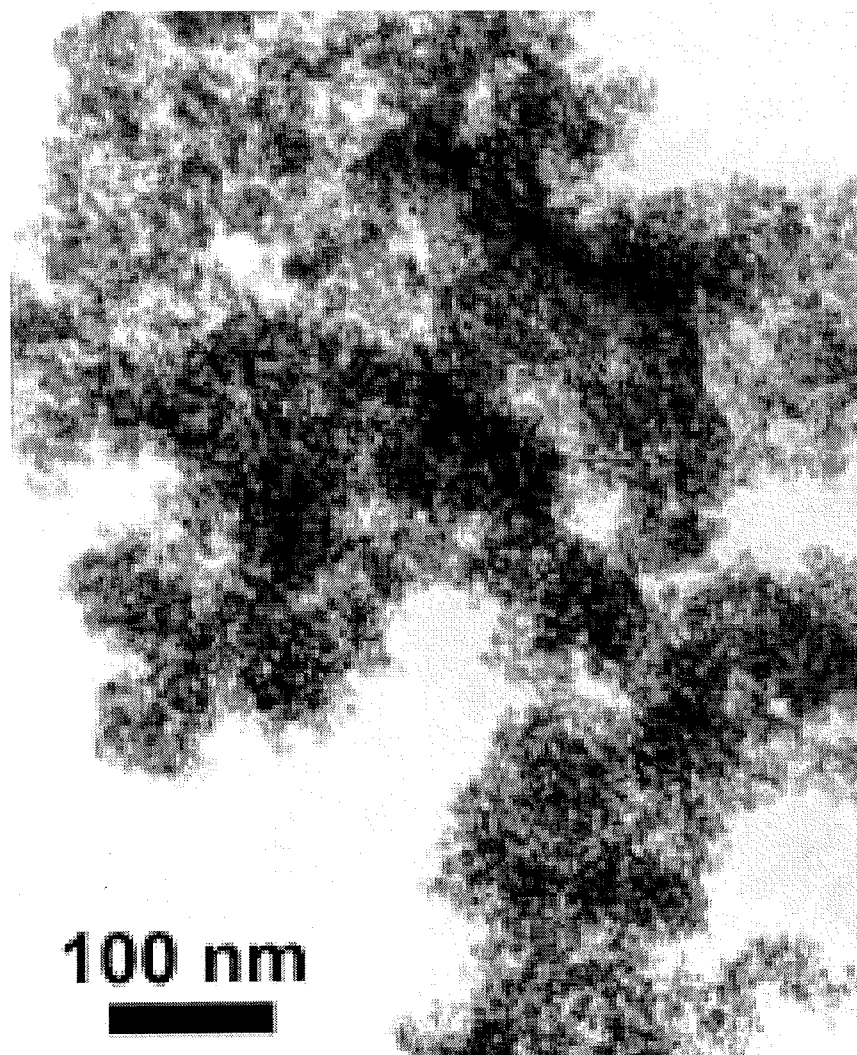
32. The method of claim 31, wherein the plastic comprises PET and the given temperature is about 265 °C.

33. The method according to claim 18, wherein the mixture provided in step (a) consists essentially of plastic, sand and SiO_x nanoparticles.

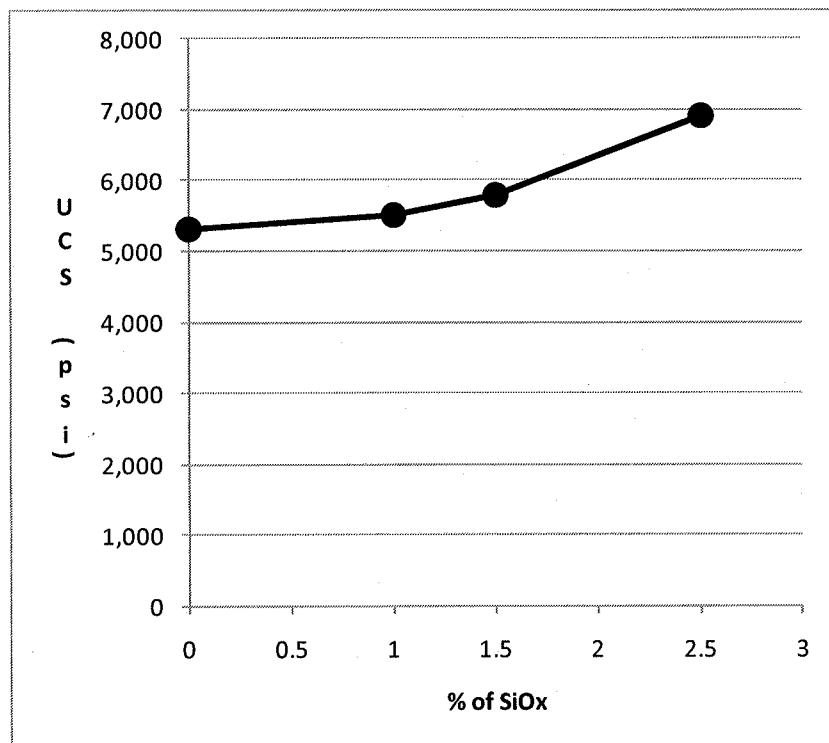
34. The method according to claim 18 wherein the plastic-based cementitious material so formed is essentially free of cementitious binders.

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FIG. 1

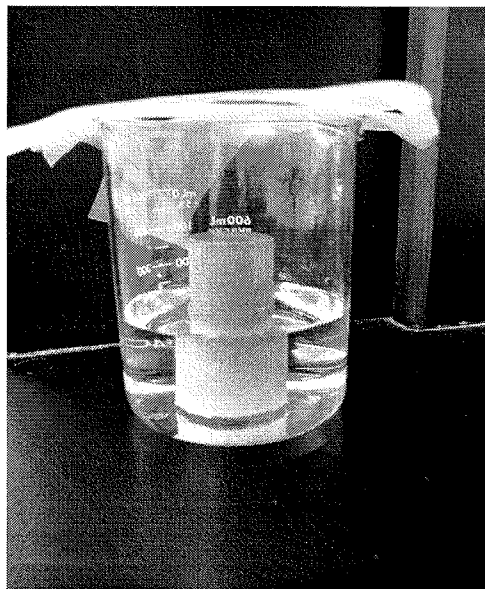


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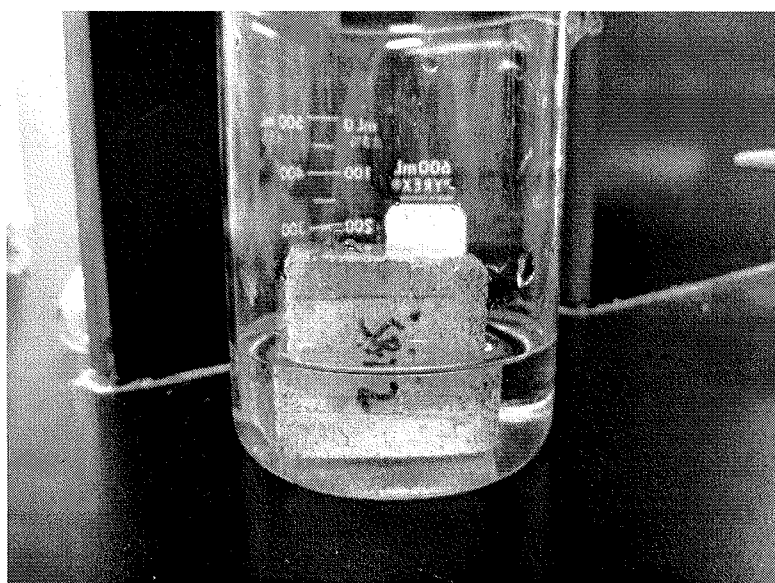
FIG. 2

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FIG. 3

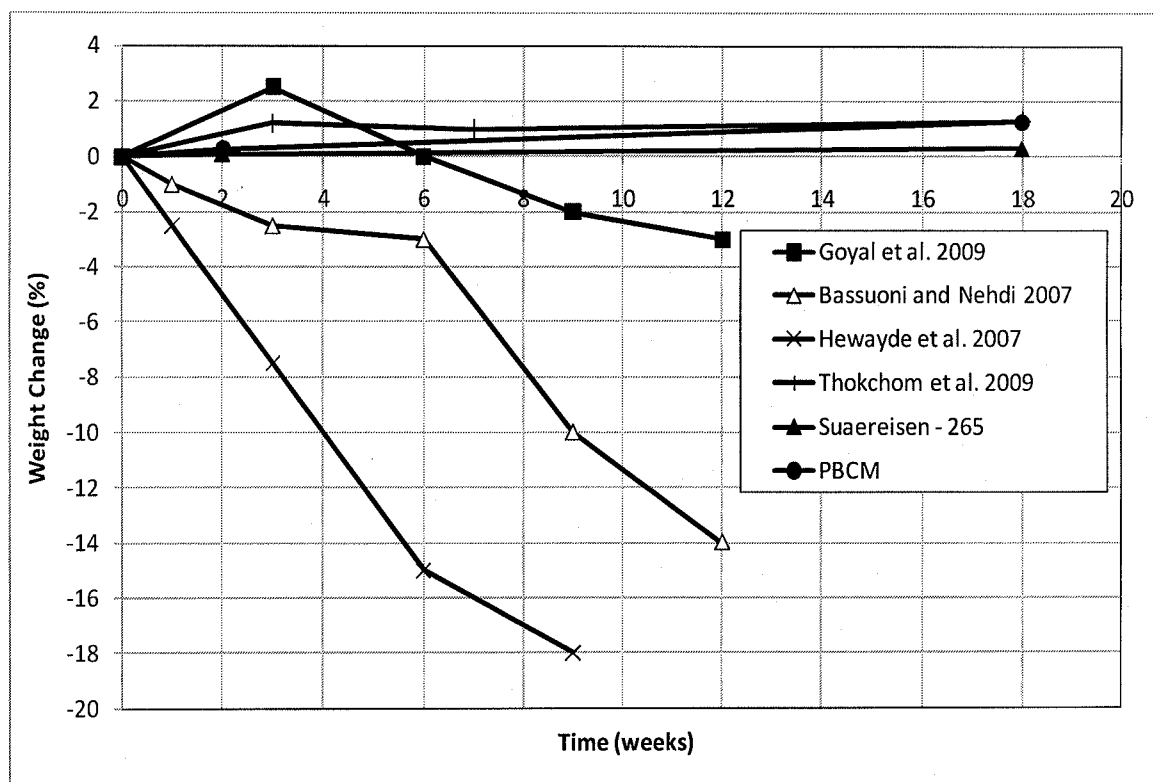


NPBC cylindrical specimen



NPBC Cubical Specimen

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FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 12/22843

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - C04B 24/24 (2012.01)

USPC - 428/327; 428/404

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - C04B 24/24 (2012.01)

USPC - 428/327; 428/404

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

IPC(8) - C04B 24/24; C04B (2012.01)

USPC - 428/327, 404, 5

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWest (PGPB,USPT,USOC,EPAB,JPAB); USPTO; Espacenet; Google Patents; Google Scholar; Wikipedia -- BINDER MATRIX
NANOPARTICLE\$ NANOPOWDER\$ PLASTIC POLYETHYLENE TEREPHTHALATE POLYMER RESIN SAND SiOx SILICON OXIDE
SURFACE AREA THERMOPLASTIC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/0047503 A1 (Godi et al.) 19 February 2009 (19.02.2009) para [0005]; [0006]; [0045]; [0047] to [0049]; [0055]; [0062]; [0063]; [0070]; [0071]; [0072]; [0077]; [0119]	1-34
Y	US 2005/0084439 A1 (Imamura et al.) 21 April 2005 (21.04.2005) para [0006]; [0014]; [0031]	1-34
Y	US 2002/0111412 A1 (Hartnett et al.) 15 August 2002 (15.08.2002) para [0001]; [0009]; [0016]; [0017]; [0023]; [0024]; [0025]	1-34
Y	US 2008/0182040 A1 (Chereau et al.) 31 July 2008 (31.07.2008) para [0006]; [0016]; [0024]; [0025]; [0071]	7,8,14,15,24,25,31,32
Y	US 4,373,058 A (Horton) 08 February 1983 (08.02.1983) col 3, ln 14-18; col 7, ln 59-64	9,26
A	US 2005/0288397 A1 (Piazza) 29 December 2005 (29.12.2005) para [0097]; claim 15	1-34
A	US 2007/0066491 A1 (Bicerano et al.) 22 March 2007 (22.03.2007) abstract	1-34

☐ Further documents are listed in the continuation of Box C.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

03 MAY 2012 (03.05.2012)

Date of mailing of the international search report

11 MAY 2012

Name and mailing address of the ISA/US

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Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT-Helpdesk: 571-272-4300

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